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Implementing Geographic Information Systems for Planning: Lessons from the History of Technological Innovation

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IMPLEMENTING GIS FOR PLANNING
LESSONS FROM THE HISTORY OF TECHNOLOGICAL INNOVATION[1]

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ABSTRACT

Geographic information systems have finally arrived in state and local governments and with them an extraordinary opportunity for planning. But many groups with differing agendas are competing to define this new technology, what it will do, and who will use it. Planners are only one such group, and it is by no means certain that they will do well in this competition. This paper mines the literature on technological innovation and concludes that planners must understand GIS as a socially constructed technology, including not just hardware and software but also the practices, laws, organizations, and knowledge that are necessary for its use. The paper makes recommendations for a strategic approach to implementation involving both human and technical systems.

GIS as an Opportunity for Planning

Across the country public agencies are finally making major investments in geographic information systems (GIS). This developing technology offers an extraordinary opportunity to empower and transform the practice of planning. GIS can help planners carry out their traditional responsibilities more effectively and with greater credibility than ever before. More significantly, GIS opens new possibilities for practice in the long term that planners and researchers have only begun to see. GIS permit the storage, retrieval, analysis, and display of a wide range of spatially referenced data,[2] some of which have never before been available.[3] With GIS, planners can link data from different sources, making once-laborious analyses easy, and entirely new ones possible. Planners can use GIS to think spatially and help citizens and policy-makers do the same.[4] In addition, GIS can easily produce vivid maps which are prohibitively expensive to prepare by hand. Planners can use the mapping capability to explore patterns, relationships, and trends, many of which would not be evident in tabulations or even complex statistical studies. Moreover, maps provide a powerful tool with which planners can work with the public.

However, planners will not necessarily use GIS in these ways. Geographic information systems are still in the developmental stages, and their ultimate forms are only partially determined. It is uncertain who will use GIS and in what ways, or even whether planners will do so in significant ways. A 20-year history of efforts to develop large-scale computing systems for planning is littered with failed attempts and massive expenditures, often with little to show as a result.[5] Successful institutionalization of large-scale computing in public agencies has been the exception rather than the rule, as managers of the systems amply testify in conference presentations and informal discussion.[6] Although the technical capabilities of GIS have increased and they have become easier to use, many of the other conditions hindering implementation continue today.

Planners can use this technology as an important part of planning, but to do so they must improve their understanding of the process of technological innovation. History suggests that technology is in great part constructed through *social* processes (Bijker et al., 1990). This idea provides a powerful framework for understanding why some innovations are adopted while others are not, and why innovations take one form rather than another. The design of a product is only a small part of an innovation, which also requires organizational and individual change, along with adaptation of the product. GIS is currently in a stage where many groups, of which planners represent only one, are vying to define the technology and to decide what problems it will solve and who will benefit by it.

This paper evaluates GIS implementation in the light of key findings in the extensive literature on technological innovation.[7] We also rely on our research in progress on GIS in state growth management programs,[8] and on a study of early efforts to develop large scale computing systems in five California planning agencies (Steiner, 1988; Innes et al, 1990).

GIS for Planning: Potential and Obstacles

Planners' responsibilities involve them in many tasks where understanding spatial patterns is essential. Local and often regional planners prepare comprehensive plans dealing with physical systems, land uses, and population patterns. They propose zoning and other land use regulations and review development permits to assess impacts. They analyze issues such as housing affordability, infrastructure capacity, or capital investment needs. Planners include staff or consultants to planning commissions and elected officials, nonprofit groups, and developers. They interact with regulatory and funding agencies as well as with citizens. They make presentations and act as educators about the issues of planning.

The scope of the opportunities GIS affords in this context is considerable.[9] Overlay maps depicting environmental hazards and fragile areas assist in evaluating potential impacts of development and provide guides to zoning. Planners can combine population and housing data for specific areas to assess the adequacy of road or sewer capacity for future development. They can maintain up-to-date files on parcels, indicating ownership, permits, zoning, and environmental characteristics and use these to offer rapid and accurate service at the zoning desk. Planners can tabulate and analyze data from these files to monitor development activity in parts of a city. They can aggregate such information within any boundaries they select and, for the first time, have the capacity to do timely and accurate analyses of neighborhood change.

Thus far, however, large-scale GIS rarely do many of these things. One explanation for this is that systems with this potential have typically been in place for only two or three years, while application development and data entry can take much longer.[10] But those designing and managing GIS are often doing so in ways that make it unlikely that GIS will do many of these planning tasks. For example, a state natural resources agency often builds and maintains a GIS for its state. This agency may include in the database only natural factors and facilities like sewage treatment plants directly related to their regulatory mandates. They give little priority to the housing, zoning, and population data that are essential for planning. Public works departments, which often maintain GIS in local governments, are interested in detailed location and capacity information on roads and sewers. Even parcel-based land records in assessors' offices may not be useful for planners because the system may not have the capability to associate these records with permit information or zoning or to compile statistics.

Because of planning's broad mission, comprehensive, multi-purpose, multi-user systems are most useful in the long run, but significant obstacles stand in the way of implementing such systems. Elected officials' concerns about costs and unnecessary duplication may be insufficient to overcome these organizational, cultural, and technical difficulties.

A multi-purpose GIS requires common data standards and agreed-upon management and access principles for all who provide or use data. Some formats and data standards are inevitably more desirable for one group or agency than another, depending on the group's record-keeping practices and responsibilities. One of the primary conflicts, for example, is over the choice of geographic scales for base maps. Agencies differ in their preferences because of the data sources they use and the tasks they do. Environmental agencies often prefer a scale of 1:24,000 because they can make use of USGS maps based on satellite photography. Some environmental analysts say their methods of identifying aquifers or wetlands, for example, are too imprecise for the larger-scale maps other agencies would prefer. But the 1:24,000 scale is of little use to public works departments and does not provide enough precision for parcel maps, though it is sufficient for regional planning studies.

Different hardware and software are better suited to one agency than another. Transportation and public works agencies, for example, often use CAD or Intergraph systems, which are most effective for point-to-point design and network analysis, whereas environmental and planning agencies prefer systems such as ARCINFO, which can perform more complex polygon-processing tasks. While new software may eventually be developed to accommodate these varying demands, GIS are likely to be institutionalized in forms that favor one or another agency or application.

The most important obstacle to GIS for planning may be planners themselves. First, planners and planning agencies are typically neither politically powerful nor well funded, so their influence on these systems is far from assured. Even if planners had power and funding, this would be insufficient because the majority of nontechnical planners and planning directors, judging by our interviews, have at best a vague notion of how they would like to use GIS. Some articulated one or two limited uses, like automating their map-making. Others have clearly unrealistic expectations, like one planning director who imagined the GIS would organize his department and ensure information could always be found. Some directors generally support GIS, but few give it a high priority. They have operated without GIS for their entire careers. Because their jobs involve working with people much of the time, often on short-term tasks, with little time for analysis, they are uncertain what GIS might offer them.

Technology as Social Construction

A popular view of technological innovation— probably the most common until recently— was that new products drive change. The idea is simple: if someone builds a better mousetrap, people will buy it and use it. Users adapt to take advantage of the product's capabilities. This idea of innovation is linear, with inventors and engineers involved in the first stages and users involved only as passive recipients of the product in the last stage. A rough survey of articles and abstracts in the Proceedings of the URISA conferences[11] suggest this linear view of innovation is common in the GIS field. Often the articles read as if developing more powerful and user-friendly applications will automatically result in the blossoming of GIS in practice. The articles' pervasive use of the term "end user" is another indicator of this linear view.

Histories of technological innovation reveal instead complex, messy, and non-linear processes. These can make sense if we understand innovation to be socially constructed rather than technology-driven. Technology is first of all more than simply artifacts. It includes the knowledge and practices to transform the capabilities of the artifacts into useful outputs.[12] Thus, GIS are not just hardware and software, but also, to name just a few elements, the knowledge of programmers and engineers, the practice of using overlay maps for environmental analysis, the laws and ordinances requiring protection of resources, the financing arrangements for planning and regulation, and the education of planners. Technology is embedded in *technological systems* (Hughes 1990), made up of many interacting subsystems, including education, production, marketing, legislation, bureaucracy, fiscal arrangements, and political processes. A successful technology depends on all systems working together.

Technology is ambiguous and uncertain until social processes define it. It has an interpretive flexibility which Weick (1990) labels "technology as equivoque." Many communities and groups influence the design and production of the artifact and shape how individuals understand and use it. In the development of plastics, for example (Bijker, 1990), some designers intended their product for luxury objects, while others envisioned a substance that could be molded and mass-produced for use in other products. Engineering advances occurred in parallel with competition among the firms and inventors to define the purpose of the new product. Eventually the mass-production goal became the accepted one, and with it, Bakelite became the standard. In the case of the bicycle, at least ten remarkably different designs competed at first for public support. The sporting enthusiasts sought speed, and other groups were more interested in safety or comfort (Pinch and Bijker, 1990). Some engineers designed for one group and some for another. Eventually the model that became the standard was the one that won bicycle races.

Similarly, GIS remains ambiguous as many groups compete to define its purposes, and various designers respond to different perceptions and objectives. System designers can plan GIS for single users and limited purposes, or they can design for multi-purpose systems combining data and objectives of a variety of users. They can conceive GIS only for expert use, or make it accessible to the lay professional, or even to the general public. GIS can focus on networks, database management, or on mapping for presentation and analysis. GIS will probably not become all of these things. The social processes now underway are likely to narrow the range of choices.

A third insight is that if innovations are genuinely integrated into practice, it happens through mutual adaptation. Users change their practices *and* the technology adapts to mesh with the users' culture. According to Rogers et al. (1977), who studied efforts to use the DIME file in local government,[13] participants began with conflicting definitions of what the technology could or should do. They debated and worked with it until they could specify its tasks. Adoption, researchers argued, is complete when the participants develop consensus on the meaning of the technology and no longer regard it as new.

Organizational factors play a crucial part in the construction of an innovation. Bikson (1987) finds, in her comparative studies of efforts to introduce computer systems, that organizational factors are better predictors of success than technical factors. The key factors are an organizational mission to implement the technology, training programs, and rewards for employees who develop capabilities to use it and some user control over the development of the technology. These features help construct an innovation that fits into the workplace.[14]

Research on the politics of computing in local governments (Perry and Kraemer, 1979; Danziger and Dutton, 1977) takes the perspective that power and resources are important determinants of which groups control the computing systems. Since planning agencies tend to have comparatively little power or resources, these researchers would probably predict that the planners will seldom be able to control multi-user GIS. We find examples, however, where planners have influenced GIS, particularly in states with growth management laws requiring all agencies to plan. But the political issues are more complex. The form a GIS takes affects power relations between agencies and among staff within agencies. It empowers those who can use the technology relative to the others, whose skills instead may become obsolete. GIS will also highlight some issues at the expense of others. Thus, many hidden political agendas play a part in implementation.

To implement a major new technology requires a strategy that manages and makes adjustments in a variety of systems. John Law (1990) has coined the term "heterogeneous engineering" to describe this task, and he offers the example of the development of navigation technology by the 15th century Portuguese as a case in point. Though the Portuguese were able sailors, they were confined to coastal exploration at limited distances. The invention of the astrolabe made it possible to measure the height of the sun. This invention became the key to a complex technological system for navigation without coastal landmarks and permitted the Portuguese to travel to more distant places than ever before. This innovation required many organizational tasks. First, designers had to simplify the astrolabe to make it a navigation tool instead of the complex research apparatus it was at the outset. Second, King John II set up a high-level scientific commission to find a system to convert measures of the sun's height into latitudes. Third, the commission developed a set of rules so that semi-educated mariners could make the conversions themselves. The government then established a major program to locate coastal features in relation to latitudes. This involved the training and deployment of skilled observers with astrolabes on many vessels. Finally, the government had to provide training courses for sailors and find ways to make the latitude information readily available.

This example has much in common with GIS. To make GIS work for planning requires changes in the practices of many agencies and individuals both as they enter and record data, and as they do their tasks of regulation, management, or planning.

Characteristics of Successful Technological Innovations

While the historical perspective suggests that to establish an important new technology requires taking many human systems into account, several specific principles can be useful guides. Rogers, in his classic work that reviews the findings on innovations across many fields (1983), identifies five principles drawn largely from research on innovation in agriculture. As we assess our findings so far, we believe these principles are equally pertinent to GIS. Each of the principles meshes with a conception that successful technology is constructed to mesh with social systems and processes.

Simplicity. One should be able to describe in 25 words or less what the technology does. A new technology must be comprehensible and meaningful to the people involved in building it, using it, and/or making decisions about it. They do not have to understand the details of how it works, but they do need a simple idea that communicates the essential capability the technology offers. For this purpose, metaphors and images are important aids.

Observable Benefits. The value of adopting the technology must be visible and concrete. Those responsible for the adoption must know what they will get, and they must be able to assess what it is worth.

Relative Advantage. Adopting a new technology has many costs, in both monetary and human terms. It entails changes in organizations, in individual behavior, in knowledge and skills, and in the daily activities of many people. Change is stressful for both individuals and organizations, and it uses time that could be spent on directly productive tasks. *For both the individuals and the agencies that adopt the innovation the benefits must exceed the costs* (Stinchcombe, 1990).

Ability to make small trials. The technology should be introduced incrementally, and changes should be reversible in the early stages. A complex technology which requires large-scale change at the outset is unlikely to be implemented. Large-scale failures have political repercussions, and hurt the agencies' chances for future funding. Benefits should accrue during these early phases.

Compatibility. The technology should be compatible with values, practices, understandings, and organizational and social structures in the community that is to use it. It should be compatible with user's language, culture, skills, and financial and management capabilities.

Characteristics of GIS Technology

The development of GIS often violates each of these conditions. GIS entrepreneurs have, however, invented a number of methods to improve the chances of success.

Simplicity. GIS are inherently complex, particularly the multi-purpose and multi-user systems. One simplification strategy is to set up GIS at the outset as a tool for only one or two important tasks. One agency uses it only for automated mapping, for example, and another for identifying critical environmental areas. But the cost of GIS is such that one or two uses will not justify them over time, and the initial uses do not automatically lead to expanded applications.

An alternative is to find an image or metaphor that captures the complexity while providing a conceptual handle for talking about it. Many planners and GIS managers we interviewed were searching for such images. Among Florida counties, which were preparing GIS to assist in complex growth management tasks such as meeting infrastructure concurrency requirements, planners and GIS managers referred to GIS as "an architecture," "an information engine, driving applications from a database," a "corporate network for efficient use of information," "a way of increasing our capacity to think about information," a way of "breaking down data barriers between departments," and the "glue" that binds departments together.

Observability of Benefits. Introducing GIS does not necessarily save an agency money. Even if in the long run automating certain activities provides savings, GIS requires technicians, staff time and training, and out-of-pocket costs. The benefits typically accrue as higher-quality service to the public and better-informed decisions. Such benefits are difficult to observe, much less to measure, and they are far in the future. Decision-makers are not generally persuaded by such arguments.

Comparatively successful GIS projects have had specific outputs that are visible and tied to legal mandates, controversial issues, or popular programs. In Rhode Island, the GIS managers got funding for much of the costly entry of basic data on soils and wetlands from a major state project to find a site for a new landfill when the only one in the state was declared closed. Proponents in Florida counties have justified GIS on grounds that they are necessary to demonstrate compliance with a tough state law on adequacy of infrastructure to serve new development. In some cases, 911 emergency response systems have provided funding for the expensive early stages of GIS, as have legislative redistricting projects.

Relative Advantage. Implementing GIS is costly to agencies in the start-up phases, and the process may offer them little in return. Unless new funds are appropriated, an agency may have little incentive to develop GIS. Not only will GIS drain its human and financial resources, its introduction will alter the power relations in the agency, require changes in how information is recorded, and generally cause conflict and disruption during an adjustment period. Planners and other potential users often have more disincentives than incentives to learn and use the system. They are likely to get little recognition from the agency managers, who would prefer they stay on top of the daily demands of the job. Even a planner who would get personal satisfaction from doing better mapping and analysis may not find the effort worthwhile.

The beneficiaries, on the other hand, are primarily members of the public who do not pay directly for GIS costs embedded in general expenditures and do not see what GIS does for them. The general public is not normally in a position to assess whether the benefits to them exceed their costs.

GIS managers have employed a variety of strategies to ensure that GIS developers and users get visible advantage from their participation and that they, in turn, support GIS. The city of Petaluma, California, funded its GIS through developer fees with the understanding that it would reduce the costs to developers of environmental impact assessments. The city hired a planner and assigned her the specific responsibility of developing the GIS for planning (Steiner 1988; Innes et al., 1990). With cutbacks in general funds, managers are building GIS databases piecemeal with grants from agencies seeking specific products. Agencies which provide data for Rhode Island's GIS have the benefit of access to the system, including the data of many other agencies. Some GIS managers mobilize specific users, including agencies, private firms, interest groups, or individuals as a political constituency for GIS.

Ability to Make Small Trials. Fortunately, fewer GIS proponents today promote completion of massive data banks before some uses and applications are in place. This strategy meant the development process took so long and cost so much that officials often withdrew funding before the system produced benefits. Moreover, system managers were less likely to identify flaws in system design before significant investment was made.

Incremental implementation is difficult with GIS. Building base maps and adding even a few data layers is costly and time-consuming. But system developers have applied ingenuity to this task. In Vermont, before the database was established or data standards agreed upon, GIS managers commissioned several state, regional, and local agencies to develop pilot applications. They also gave local governments aerial photos to identify sites important for their planning. The state agency then entered this information on computerized maps and returned them to the localities. These strategies allowed agencies to learn some features of GIS, to start databases, and to begin to imagine what they would do with them. In Montgomery County, Maryland, planners first built a pilot GIS for a small area, including all the intended data layers, as a test of the system they intended to use for the county as a whole. A number of agencies have developed early stages of GIS with prototypes (Zetlan and Somers, 1991; Rourk, 1989; McMillen, 1991).

Compatibility. The greatest challenge is to achieve compatibility between GIS and the users' activities, organization, and culture. Using GIS will require planners to change the way they think and work. Many are unskilled in the use of computers and few have expertise in GIS. They do not understand computer language or logic. Our research shows disinterest, even distrust, in computer systems among some planning directors. A second compatibility problem is that GIS requires cooperation between agencies that do not normally work together and may even be in conflict. The staff of these agencies often have different professional perspectives, technical abilities, and information needs.

One approach is to begin by simply automating existing tasks for individual agencies. One example is land records systems permitting retrieval of parcel information by address for planners to use at the zoning desk. Such efforts can be the starting point for a multiuse GIS once users become accustomed to the system, but they might also be the only application.

The most effective strategy is to set up consensus-building groups like the steering committees and working groups that have been established in many jurisdictions around the country to help implement GIS (Warnecke, 1992; Innes 1992a). These committees have members drawn from the participating agencies and sometimes include private-sector users, vendors, academic researchers, and interested citizens. They may include both technical and non-technical members with the idea that they can learn from each other. These groups manage the development of the technology, develop a common language, learn from problems as they arise in implementation, and seek consensus on matters of common importance such as hardware and software choices, data formats and standards, access principles, ways of sharing costs, and priority projects for development.

These groups are most likely to be effective if they are run in ways that assure all members have a voice, communication and mutual learning takes place, and that the objective is to search for common ground. The group must be permitted to challenge assumptions or re-define issues if they are to be creative in the task (Innes, 1992a).

Such groups can take on the role Law describes of heterogeneous engineers. They can speed up the slow process of socially constructing a technology through trial and error, competition, and existing networks of communication. Instead, the groups establish new communication networks and develop shared meaning for the technology, while designing it to fit with a variety of agencies, contexts, and tasks.

Conclusions and Recommendations

What then can planners do to help assure that GIS will be implemented for planning?

Develop a Vision of GIS for Planning. Planning as a field and planners as individuals must develop a vision of what GIS can be. To do this will require education and imagination, not only for junior planners, but more importantly for planning directors. It also requires outreach by technically oriented planners who understand GIS. Planners must then find ways to incorporate this vision into the missions of city governments and planning agencies.

The task of developing a vision also requires serious attention from academic researchers and theorists to explore the implications of this new opportunity for planning. They should draw on the ample literature of technological innovation and management information systems to develop a framework for planners and planning educators to use. On the other hand, those with GIS expertise should pay much more attention to the social context in which GIS must operate.[15] The applications have far outstripped the ability of planning to absorb or use them.

Follow the Rule of Simplicity. GIS implementors must simplify this tool, stripping away unnecessary bells and whistles to make it accessible to those who are semi-educated in computers. Planners and GIS managers should seek the image or metaphor that will capture the vision of GIS. This image will play a central and self-fulfilling role in the social construction of this technology.

Rely on Consensus-Building Groups. Jurisdictions should set up steering committees and working groups with a broad mandate to address all systems that are potentially part of this technology. These groups should include representatives of all who have a stake in GIS, and they should be managed as consensus-building groups. Planners should play an important part in such groups.

Implement Incrementally. Whenever possible, GIS managers should introduce users to GIS in simple and inexpensive forms before building full-fledged systems. They should begin with prototypes, bottom-up development of applications, and simple tasks. Planners should identify and implement some of the simple and readily available planning applications immediately[16] to begin the learning process.

Assure Benefits are Visible and Early. System managers should start with projects that have significant, visible benefits. Typically these tie to activities that are popular, legally required, or offer significant savings. Planners should identify applications linked to local planning requirements and with visible benefits for this first stage.

Assure Benefits to Those Who Pay for GIS Development. Planning departments should create supportive environments for those who build and learn GIS, giving planners time and recognition for this work. Managers should explicitly build constituencies for GIS among public and private users, and provide new services to the public that they can associate clearly with GIS. Planners and GIS managers should systematically market GIS to its beneficiaries.

Be Patient and Persistent. The process of socially constructing an innovative and significant technology is slow. It has setbacks and unanticipated consequences. GIS offers payoffs for the future of planning that will make the enterprise worth the effort.

NOTES

[1]Conversations with Norman Smothers were helpful in framing the argument for this article.

[2]For those unfamiliar with GIS, Huxhold (1991) and Burrough (1986) are good introductory texts.

[3]Technologies like GPS (Global Positioning Systems), remote sensing, and orthophotogrammetry permit the entry into GIS of natural resource and other data on the environment that would otherwise be technically or financially infeasible to obtain, much less to manage in a database.

[4]Obermeyer (1991), drawing on evidence from professional journals, contends that planners tend to think spatially and use maps more than public administrators, though both often fail to highlight the spatial dimensions of many issues they study. In general, policy-makers have not given much attention to spatial implications of policies (except for political boundaries and redistricting). We believe this inattention can be in great part explained by the fact that these patterns have not been made salient in presentation materials.

[5]Innes et al., 1990, show this pattern in case studies of five jurisdictions which were leaders in the efforts to develop computing systems for planning. Workshops held with local computer systems managers as part of this study confirmed this contention. The pattern of implementation failure of large-scale systems holds across not only planning but many other public agencies.

[6]These failures are very little documented or explained, however. System managers understandably prefer to publish success stories.

[7]Good literature reviews and insightful research on innovation which have broadly informed this essay include Bijker et al., eds, 1990; Bikson et al., 1981; Goodman et al., 1990; Kraemer and Perry, 1989; Rogers, 1983; Rogers et al., 1977; Smothers, 1981; Tornatsky et al., 1983; and Yin, 1981.

[8]This research has involved case studies of five states which have instituted state growth management: Florida, New Jersey, Vermont, Maine, and Rhode Island. Interviews were conducted with planners, GIS managers, and other participants in 1989-1990. A second round of interviews has started in 1992. Two papers have been published thus far (Innes, 1992a, 1992b).

[9]Levine and Landis (1989) and Marble and Amundsen (1988) provide excellent overviews of planning applications of GIS.

[10]Some jurisdictions, however, began to set up GIS as early as the late 1960s. While the technology was less user-friendly and the mapping capabilities minimal, many of the organizational and planning issues differed little from current ones.

[11]URISA refers to Urban and Regional Information Systems Association. The conferences of this Association are where those most involved in GIS for planning are likely to participate.

[12]This definition is drawn from Weick, 1990. See also Eveland, 1986.

[13]The DIME file (Dual Independent Map Encoded file system) was the first version of the Census' Bureau's program for address matching and computerizing street networks (Parent and Church, 1987). It has been superseded by the TIGER file (Topologically Integrate Geographic Encoding and Reference System).

[14]Campbell (1991) also offers an insightful analysis of organizational factors in the utilization of GIS. She notes that there has been little study of the actual benefits for users of innovations. This factor may well play a significant part in user adoption. Somers (1989) provides a useful perspective on organizational change and GIS.

[15]This recommendation is inspired by two presentations given by Britton Harris in Oxford, England, one at the Conference on Computers in Planning and the other at the Association of Collegiate Schools of Planning Annual Conference in 1991.

[16]Even when a planning agency is not yet linked into large-scale GIS, simple mapping programs, for example, introduce the possibilities of the technology.

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